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| 10/589,794 | 08/17/2006 | Sven Woop | 119835-163886 | 8682 |
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| SCHWABE, WILLIAMSON & WYATT, P.C. 1420 FIFTH, SUITE 3400 SEATTLE, WA 98101-4010 | | | HOANG, PHI | |
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

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|------------------------------|--------------------------------------|------------------------------------|
| Office Action Summary | Application No. 10/589,794 | Applicant(s) WOOP ET AL. |
| | Examiner PHI HOANG | Art Unit 2628 |

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If no period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) Responsive to communication(s) filed on 03 February 2010.
 2a) This action is FINAL. 2b) This action is non-final.
 3) Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) Claim(s) 17-39 is/are pending in the application.
 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
 5) Claim(s) _____ is/are allowed.
 6) Claim(s) 17-39 is/are rejected.
 7) Claim(s) _____ is/are objected to.
 8) Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) The specification is objected to by the Examiner.
 10) The drawing(s) filed on _____ is/are: a) accepted or b) objected to by the Examiner.
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
 11) The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 a) All b) Some * c) None of:
 1. Certified copies of the priority documents have been received.
 2. Certified copies of the priority documents have been received in Application No. _____.
 3. Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) Notice of References Cited (PTO-892)
 2) Notice of Draftsperson's Patent Drawing Review (PTO-948)
 3) Information Disclosure Statement(s) (PTO/SB/08)
 Paper No(s)/Mail Date 16 April 2010.
- 4) Interview Summary (PTO-413)
 Paper No(s)/Mail Date: _____.
 5) Notice of Informal Patent Application
 6) Other: _____

DETAILED ACTION

Response to Arguments

1. Applicant's arguments filed 23 March 2010 have been fully considered but they are not persuasive.
2. With regard to claims 17, 24, and 32, Applicant states, "Lathrop's space-based graph does not prevent objects from being intersected with a node more than once, and cannot teach "after the object of intersection is stored in the list, preventing, by the computing device, further performing of intersection computations after performing the first intersection computation between the object and the ray" as recited in claim 17." However, Lathrop further discloses division of the nodes of the directed acyclic graph (DAG) into additional child nodes. Lathrop (Column 9, lines 9-54) discloses steps for subdivision of nodes. Step 3 provides for subdivision of a node if there are too many objects contained within if it exceeds a certain predetermined threshold. Therefore, Lathrop discloses creation of a list (DAG) is comprised of nodes where the nodes can be divided into additional nodes based on a predetermined threshold (for example, one) limiting the number of objects referenced by the node. As a result, the intersection of a ray is only performed once per node as described by Lathrop (Column 7, lines 57-62), where nodes that are subdivided can have any number of objects up to a predetermined threshold (i.e., one).

Since the position of the Examiner on claims 17, 24, and 32 is maintained, the Examiner's position on claims 18-23, 25-31, and 33-39 is also maintained.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claim 17-29 and 32-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Lathrop (US 6,597,359 B1).
5. Regarding claim 17, Wrigley discloses a method for rendering three-dimensional scenes on a display of a computing device, the method comprising: rendering the three dimensional scenes, by the computing device, by means of ray-tracing; (Figure 1 and column 4, lines 47-58)

establishing, by the computing device, a ray-tracing acceleration structure having a plurality of objects; (Figure 6 and column 6, lines 65-67)

traversing, by the computing device, a ray through the acceleration structure until an object of intersection is identified; (Column 6, lines 35-64)

performing a first intersection computation between the object of intersection and the ray; (Column 6, lines 53-61)

storing, by the computing device, the object of intersection in a list; (Figure 6, internal tree representation)

Wrigley does not clearly disclose after the object of intersection is stored in the list, preventing, by the computing device, further performing of intersection

computations after performing the first intersection computation between the object and the ray.

Lathrop discloses after the object of intersection is stored in the list (Figures 4-9), preventing, by the computing device, further performing of intersection computations after performing the first intersection computation between the object and the ray (Column 7, lines 57-62, where objects can be subdivided until it is represented by a single node, column 9, lines 28-30).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

6. Regarding claim 18, Wrigley discloses determining, by the computing device, whether an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and when the affirmative decision is not possible, deciding, by the computing device, by making a conservative decision as to whether the triangle overlaps the node (Column 18, line 64 – column 19, line 40).

7. Regarding claim 19, Wrigley discloses computing, by the computing device, a three dimensional ray space occupied by a ray according to the ray's increasing

distance from a virtual source; (Column 9, lines 9-12)

traversing, by the computing device, the ray space; (Column 9, lines 12-14)

and processing, by the computing device, selected objects identified within the ray space (Column 9, lines 14-28).

8. Regarding claim 20, Wrigley discloses the ray space is a selected one of a cone or a pyramid, and the method further comprises processing, by the computing device, objects within the ray space, and ordering the objects according to the objects' virtual distances from the virtual source of the ray (Figure 2).

9. Regarding claim 21, Wrigley in view of Lathrop discloses the ray-tracing acceleration structure further comprises at least one acceleration structure node, with each node being associated with a region of node space, and the method further comprises (Wrigley, Figure 6): storing, by the computing device, simplified geometry data associated with each acceleration structure node which omits one or more triangles from geometry data for the node (Wrigley, Figure 6 and column 6, lines 35-47, envelopes) which omits one or more triangles from geometry data for the node (Lathrop Column 9, lines 9-39);

and computing, by the computing device, a ray-object intersection, using the simplified geometry data to compute the ray-object intersection when the ray space overlaps a majority of the node space (Wrigley, Column 6, lines 48-64).

10. Regarding claim 22, Lathrop discloses subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and

column 7, lines 39-62)

classifying, by the computing device, the objects as primitive or non-primitive;
(Column 9, lines 31-34)

traversing a ray through the acceleration structure until an intersected object is identified; (Column 9, lines 9-18)

and after traversing the ray if the identified object is not a primitive object, storing, by the computing device, affine transformation data which transforms the object and ray into a coordinate system locally associated with the identified object, and traversing the local coordinate system and storing affine transformation data, recursively, until the ray intersects with a primitive object; (Column 10, lines 49-67)

and if the identified object is a primitive object, storing by the computing device, transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersecting the transformed ray with the transformed identified object, and storing, by the computing device, ray-object intersection data (Column 11, lines 1-19).

11. Regarding claim 23, Lathrop discloses subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and column 7, lines 39-62)

recursively instantiating, by the computing device, a plurality of sub-objects, the sub-objects having a similar geometry; (Column 8, lines 32-49)

and building, by the computing device, a next level object by, at least in part,

using the plurality of instantiated sub-objects with similar geometry (Column 8, line 64 – column 9, line 8).

12. Regarding claim 24, Wrigley discloses An apparatus for rendering three-dimensional scenes, the apparatus comprising: a processor; (Figure 9, element 74)

a tangible computer-accessible storage medium operatively coupled to the processor; (Figure 9, element 70)

a ray-tracing acceleration structure stored in the storage medium, the acceleration structure having object data for a plurality of objects; (Figure 6 and column 6, lines 65-67)

Wrigley does not clearly disclose a ray-casting module operatively configured to traverse rays through the acceleration structure and return ray-object intersection data, the ray-casting module comprising a decision unit operatively configured such that, when ray-object intersection data has been computed for a given ray and a given object, the decision unit prevents additional ray-object intersection computations from being carried out for the given ray and the given object.

Lathrop (Figures 4-9) discloses a ray-casting module operatively configured to traverse rays through the acceleration structure and return ray-object intersection data, the ray-casting module comprising a decision unit operatively configured such that, when ray-object intersection data has been computed for a given ray and a given object, the decision unit prevents additional ray-object intersection computations from being carried out for the given ray and the given object (Column 7, lines 57-62).

Therefore, it would have been obvious to a person of ordinary skill in the art at

the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

13. Regarding claim 25, Wrigley discloses determining if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is possible, store the affirmative decision as part of establishing the acceleration structure (Column 18, line 64 – column 19, line 32).

14. Regarding claim 26, Wrigley discloses if the affirmative decision is not possible, a conservative decision as to whether the triangle overlaps the node and store the conservative decision as part of establishing the acceleration structure (Column 19, lines 33-40).

15. Regarding claim 27, Wrigley discloses the ray-casting module further comprises a traversal unit, the traversal unit operatively configured to: compute a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

and traverse the ray space through the acceleration structure from the virtual source of the ray through an increasing virtual distance from the virtual source of the ray. (Column 9, lines 12-14)

16. Regarding claim 28, Wrigley discloses the ray space traversed is a selected one of a cone or a pyramid (Figure 2).

17. Regarding claim 29, Wrigley in view of Lathrop discloses at least one acceleration structure node, each node being associated with a region of node space; (Wrigley, Figure 6)

and wherein the ray casting module is further configured to store simplified geometry data associated with each acceleration structure node; (Wrigley, Figure 6 and column 6, lines 35-47, envelopes) which omits one or more triangles from geometry data for the node (Lathrop Column 9, lines 9-39);

and, when the ray space overlaps a majority of the node space, compute ray-object intersection using the simplified geometry data (Wrigley, Column 6, lines 48-64).

18. Regarding claim 32, Wrigley discloses an article of manufacture comprising a tangible computer-accessible storage medium (Figure 9, element 70) for digitally storing a plurality of programming instructions designed to program an apparatus to render three-dimensional scenes by means of ray-tracing, wherein the programming instructions, if executed by the apparatus, enable the apparatus to: establish ray tracing acceleration structures having a plurality of objects (Figure 6 and column 6, lines 35-67).

Wrigley does not clearly disclose for an object for which an intersection computation has been performed with a ray, preventing further performing of intersection computations between the objects and the ray.

Lathrop discloses for an object for which an intersection computation has been performed with a ray, preventing further performing of intersection computations between the objects and the ray (Column 7, lines 57-62, where objects can be subdivided until it is represented by a single node, column 9, lines 28-30).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

19. Regarding claim 33, Wrigley discloses determining if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is not possible, decide by making a conservative decision as to whether the triangle overlaps the node (Column 18, line 64 – column 19, line 40).

20. Regarding claim 34, Wrigley discloses computing a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

traverse the ray space through the acceleration structure; (Column 9, lines 12-14)

and process selected objects identified within the ray space (Column 9, lines 14-28).

21. Regarding claim 35, Wrigley discloses the ray space traversed by the ray is a selected one of a cone or a pyramid, and the programming instructions, if executed, further enable the apparatus to process the objects within the ray space, and order the objects according to the objects' virtual distances from the virtual source of the ray (Figure 2).

22. Regarding claim 36, Wrigley in view of Lathrop discloses storing simplified geometry data associated with each acceleration structure node (Wrigley, Figure 6 and column 6, lines 35-47, envelopes) which omits one or more triangles from geometry data for the node (Lathrop Column 9, lines 9-39);

and when the ray space overlaps a majority of the node space, compute ray-object intersection, using the simplified geometry data (Wrigley, Column 6, lines 48-64).

23. Regarding claim 37, Lathrop discloses subdividing the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and column 7, lines 39-62)

classifying the objects as primitive or non-primitive; traversing a ray through the acceleration structure until an intersected object is identified, if the identified object is not a primitive object, store affine transformation data which transforms the object and ray into a coordinate system locally associated with the identified object, and traverse the transformed ray through the local coordinate system and store affine transformation data, recursively, until the ray intersects with a primitive object; (Column 10, lines 49-67)

and if the identified object is a primitive object, store transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersect the transformed ray with the transformed identified object, and store ray-object intersection data (Column 11, lines 1-19).

24. Regarding claim 38, Lathrop discloses subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; (Figure 5 and column 7, lines 39-62)

recursively instantiating a plurality of sub-objects, the sub-objects having a similar geometry; (Column 8, lines 32-49)

and building a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry (Column 8, line 64 – column 9, line 8).

25. Claims 30, 31 and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Lathrop (US 6,597,359 B1) and further in Lee et al. (US 2004/0233222).

26. Regarding claim 30, Wrigley in view of Lathrop discloses all limitations as discussed in claim 24.

Lathrop further discloses a transformation unit(Column 11, lines 1-19); and a ray casting unit (Figure 3, element 15).

Wrigley in view of Lathrop does not clearly disclose a matrix unit; wherein the matrix unit is operatively configured to send affine transformation matrices of object data to the transformation unit, each affine transformation matrix being a selected one of an object-space transformation matrix and a normalized space transformation matrix, and

Art Unit: 2628

the transformation unit is further operatively configured to receive a ray from the ray casting unit and transform the ray into the object's affine transformation matrix's coordinate system.

Lee discloses performing affine transformations using an affine transformation matrix (Paragraphs 0046 and 0047).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wrigley in view of Lathrop to performing a transformation using an affine matrix as disclosed by Lee because a simpler coordinate system can be obtained while preserving collinearity after the transformation.

27. Regarding claim 31, Lathrop discloses an acceleration structure computation unit operatively configured to subdivide the plurality of objects into an n-level hierarchy of objects and sub-objects and store data classifying the objects as primitive or non-primitive; (Figure 5 and column 7, lines 39-62)

a traversal unit operatively configured to traverse a ray through the acceleration structure until a potential ray-object intersection is identified; (Column 12, lines 60 – column 13, line 3)

and an intersection computation unit; (Column 13, lines 3-10)

wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the transversal unit for recursive processing until the ray intersects with a primitive object, if the object identified by the traversal unit is not a primitive object; (Column 10, lines 49-67)

and wherein, the transformation unit is operatively configured to send the object's

Art Unit: 2628

affine transformation matrix data and the transformed ray data to the intersection computation unit, if the object identified by the traversal unit is a primitive object (Column 11, lines 1-19).

28. Regarding claim 39, Wrigley discloses a ray casting processor for rendering dynamic three-dimensional scenes, the processor comprising: a traversal unit, the traversal unit being coupled to a plurality of node caches for storing acceleration structure node data, the node data structured to improve accessibility according to ray coherence, the node caches arranged in an n-level hierarchy; (Figure 6 and column 6, lines 35-67)

a list unit, the list unit being coupled to a plurality of list caches for storing lists of object addresses for objects that have already been intersected by a ray, the list caches arranged in an n-level hierarchy (Figure 6, internal tree representation).

Wrigley does not clearly disclose the list unit having a decision unit, the decision unit configured to prevent objects whose object addresses are stored in the list from being intersected again by the ray.

Lathrop discloses techniques for reducing the number of ray to object intersection checks depending on the number of objects (Column 7, lines 57-62).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley's division of objects into envelopes, by minimizing ray to object intersection checks as disclosed by Lathrop because computational performance is increased by not being required to perform unnecessary checks.

Wrigley in view of Lathrop does not clearly disclose a matrix loading unit, the matrix loading unit being coupled to a plurality of matrix caches for storing affine transformations in the form of matrices, the matrix caches arranged in an n-level hierarchy.

Lee discloses performing affine transformations using an affine transformation matrix (Paragraphs 0046 and 0047).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wrigley in view of Lathrop to performing a transformation using an affine matrix as disclosed by Lee because a simpler coordinate system can be obtained while preserving collinearity after the transformation.

Conclusion

29. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to PHI HOANG whose telephone number is 571-270-3417. The examiner can normally be reached on Mon-Fri, 8:30am-5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Xiao Wu can be reached on 571-272-7761. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Phi Hoang/
Examiner, Art Unit 2628
May 20, 2010

/XIAO M. WU/
Supervisory Patent Examiner, Art Unit 2628